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ABSTRACT

Fourth grade children read experimental lessons, each of which presented one of the following: (1) a concept definition and placebo material; (2) a rational set of examples and nonexamples of the concept and placebo material; (3) the definition, a rational set, and placebo material; or (4) the definition and three different rational sets. Control children read the placebo material only. Each experimental group performed significantly better than the controls; and children reading a lesson with a definition and three rational sets performed significantly better than those who received only a definition. The use of rational sets of concept instances and of a concept definition is validated as a powerful controllable variable in instructional material. (Author)

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THE EFFECTS OF A DEFINITION AND A VARYING NUMBER OF EXAMPLES AND NONEXAMPLES ON CONCEPT ATTAINMENT

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REPORT FROM THE PROJECT ON CONCEPTUAL SKILLS OF SCHOOL LEARNING AND INSTRUCTIONAL STRATEGIES

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Technical Report No. 280

THE EFFECTS OF A DEFINITION AND A VARYING NUMBER OF EXAMPLES AND NONEXAMPLES ON CONCEPT ATTAINMENT

by

Herbert J. Klausmeier and Katherine Vorwerk Feldman

Report from the Project on
Conditions of School Learning and
Instructional Strategies

Wisconsin Research and Development
Center for Cognitive Learning
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Statement of Focus

Individually Guided Education (IGE) is a new comprehensive system of elementary education. The following components of the IGE system are in varying stages of development and implementation: a new organization for instruction and related administrative arrangements; a model of instructional programing for the individual student; and curriculum components in prereading, reading, mathematics, motivation, and environmental education. The development of other curriculum components, of a system for managing instruction by computer, and of instructional strategies is needed to complete the system. Continuing programmatic research is required to provide a sound knowledge base for the components under development and for improved second generation components. Finally, systematic implementation is essential so that the products will function properly in the IGE schools.

The Center plans and carries out the research, development, and implementation components of its IGE program in this sequence: (1) identify the needs and delimit the component problem area; (2) assess the possible constraints—financial resources and availability of staff; (3) formulate general plans and specific procedures for solving the problems; (4) secure and allocate human and material resources to carry out the plans; (5) provide for effective communication among personnel and efficient management of activities and resources; and (6) evaluate the effectiveness of each activity and its contribution to the total program and correct any difficulties through feedback mechanisms and appropriate management techniques.

A self-renewing system of elementary education is projected in each participating elementary school, *i.e.*, one which is less dependent on external sources for direction and is more responsive to the needs of the children attending each particular school. In the IGE schools, Center-developed and other curriculum products compatible with the Center's instructional programing model will lead to higher student achievement and self-direction in learning and in conduct and also to higher morale and job satisfaction among educational personnel. Each developmental product makes its unique contribution to IGE as it is implemented in the schools. The various research components add to the knowledge of Center practitioners, developers, and theorists.

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Abstract

Fourth-grade children read experimental lessons, each of which presented one of the following: a concept definition and placebo material; a rational set of examples and nonexamples of the concept and placebo material; the definition, a rational set, and placebo material; or the definition and three different rational sets. Control children read the placebo material only. Each experimental group performed significantly better than the controls; and children reading a lesson with a definition and three rational sets performed significantly better than those who received only a definition. The use of rational sets of concept instances and of a concept definition is validated as a powerful controllable variable in instructional material.

1
Introduction

A concept may be attained by an individual at any of four successively higher levels: the concrete level, the identity level, the classificatory level, and the formal level. Maturing children learn many of their concepts by attaining them at these successively higher levels. The external conditions of learning and the internal conditions involved in the attainment at each level have been postulated and described by Klausmeier, Ghatala, and Frayer (in press).

The external conditions pertain to availability of the examples and nonexamples (EX), emphasizers (cues) that facilitate discrimination between the examples and nonexamples (EM), and concept definitions (D). Other external conditions (O), including feedback and the use of synonyms and metaphors, can also be facilitative. Internal conditions associated with the learner (IC), such as his attentiveness to the task; his ability to perform various essential mental operations including discriminating, generalizing, remembering, hypothesizing, and evaluating; and his attainment of the concept at the earlier levels are also determining factors. Thus, concept attainment (CA) may be viewed as a function of various sets of instructional conditions interacting with internal conditions of the learner. CA = f(EX + EM + D + O) x (IC).

The critical instructional conditions in concept attainment are being identified. In particular, conditions associated with the presentation of examples and nonexamples and concept definitions in instructional material have been studied in many settings with students of varying characteristics. Providing the learner with examples and nonexamples of the concept has been found to be most effective when the examples vary widely in irrelevant attributes while the nonexamples differ from the examples in (if possible) only one relevant attribute at a time (Feldman, 1972; Markle & Tiemann, 1969, 1972; Swanson, 1972; Tennyson, 1973; Tennyson, Woolley, & Merrill, 1972). A set of examples and nonexamples that manifest these characteristics has been labeled a "rational set" (Markle & Tiemann, 1969). Definitions have been shown to be particularly facilitative when stated in terms of the relevant attributes of the concept and when written at an appropriate level for the learner (Feldman & Klausmeier, 1974; Markle & Tiemann, 1972).

The relative effectiveness, however, of a rational set of examples and nonexamples and of a concept definition, when used separately or in combination, has not been determined. Since both a concept definition and a rational set of examples and nonexamples potentially supply all the essential information about the relevant attributes of the concept, it is possible that equal amounts of information might actually be secured from each source. Yet instances are usually a nonverbal source of information, while a concept definition is a verbal source. The information supplied by each, while similar, is not identical. Subjects presented with both sources of information might, therefore, be expected to learn more from the combination of the two than they would from either source alone.

While several researchers have investigated the facilitative effects of a rational set as contrasted with a definition and the combined effect of both factors presented jointly, their results are inconclusive. For example, Feldman (1972) found that subjects performed better when presented with a rational set and a definition than when presented with a rational set alone, but Swanson (1972), using an identical paradigm with different materials, found the opposite result. Both of these experiments were conducted in school settings and used concepts drawn from usual school subject matters. Merrill and Tennyson (1971) reported that a definition was equally as

effective as instances and that the two in combination were more effective than either one presented singly. However, deviation from predicted scores rather than the absolute number of correct or incorrect responses was used as the dependent measure. More important, no experiment has yet been undertaken to determine the effects of varying the number of times the subject is presented with a definition or a rational set, although Markle and Tiemann (1972) indicate that in certain cases continued practice with the same or several rational sets may be necessary for full mastery of any particular concept.

The present study was conducted to ascertain precisely the effects of presenting a single rational set of examples and nonexamples, a single concept definition, a rational set combined with a concept definition, and three rational sets combined with the definition. Subjects were fourth-grade students. It was predicted that performance on a classification task would not differ between subjects presented with a rational set and subjects presented with a definition, but that subjects presented with both sources of information would do better than subjects presented with only one. Additionally, it was expected that subjects given the definition and three rational sets would perform better than subjects presented with the definition and only one rational set. The presumption here was that additional information would be secured from each new rational set.

II
Method

Subjects

The subjects were 134 fourth-grade students from two elementary schools in a Wisconsin suburban community. Subjects were stratified into three groups (high, medium, and low) on the basis of grade equivalency scores obtained in reading on the Iowa Tests of Basic Skills administered during the fall of the school year. The mean score for all subjects was 4.2 years. Mean scores for the high, medium, and low stratification levels were 5.3, 4.0, and 2.9 respectively. Experimental lessons and testing materials were administered in classroom groups.

Materials

Lessons

The concept used as the subject matter in the experiment was *equilateral triangle*. Four printed lessons were developed to teach the concept by various means as follows: (1) by presenting a definition of the concept without examples and nonexamples (Lesson D); (2) by presenting a rational set of three examples (drawings of equilateral triangles) and five nonexamples (drawings of geometric shapes other than equilateral triangles) (Lesson RS_1); (3) by presenting a definition and a rational set of three examples and five nonexamples (Lesson DRS_1); and (4) by presenting a definition and three different rational sets of three examples and five nonexamples (Lesson DRS_{1-3}). The identical rational set of examples and nonexamples was used in Lessons RS_1 and DRS_1, and it was also presented once in Lesson DRS_{1-3}. Three placebo lessons dealing with the concepts *number systems*, *roman numerals*, and *geometry* were also developed. Each of the four treatment lessons and the set of placebo lessons defined an experimental condition.

The first page of each treatment lesson began with an identical short paragraph stating that the lesson dealt with equilateral triangles. The paragraph was followed by one of three things, depending on the type of lesson: the definition of *equilateral triangle* displayed in a box; an example of an *equilateral triangle*; or the definition and an example. The additional instances given in Lessons RS_1, DRS_1, and DRS_{1-3} were presented on subsequent pages. The definition was presented before each additional rational set in Lesson DRS_{1-3}. (It was presumed that including the definition with each set was essential to prevent forgetting but would not provide new or additional information.) On each page of every lesson, the subjects were instructed to study carefully the material which was presented.

The definition of equilateral triangle used in the lessons specified each of the major relevant attributes of the concept. No irrelevant attributes were included, and no attempt was made to define or explain the relevant attributes. The definition read: "An equilateral triangle is a figure with three straight sides of equal length. It is plane, closed, and simple."

Procedures outlined by Markle and Tiemann (1969) were used in constructing the rational sets. Examples comprising each set varied in irrelevant attributes (size, orientation, and solid or line drawing) while nonexamples differed from examples in respect to only one or two defining (major relevant) attributes at a time. Additionally, the instances selected for each rational set represented a range of difficulty or obviousness. Difficulty was determined by an instance probability analysis carried out on a subsample of the target population (Feldman &

Klausmeier, 1974) according to procedures outlined by Woolley and Tennyson (1972).

All the lessons were presented in printed, self-instructional booklets. The booklets for Lessons RS_1, DRS_1, and each of the placebo lessons were five pages long. Lesson DRS_{1-3} was 15 pages long and was presented in three 5-page booklets. (The first of these lesson booklets was identical to the booklet for Lesson DRS_1.) As Lesson D consisted of only the definition placed on the first page, four pages of placebo material were added so that the lesson booklet was equal in length to the other booklets.

In order to equate the total time spent reading lessons across conditions, all subjects read three different lesson booklets and were paced through each booklet by the experimenter. In addition to their treatment lesson, subjects in Conditions D, RS_1, and DRS_1 read two of the placebo lessons that were prepared for the control subjects. Subjects in Condition DRS_{1-3} read three treatment lessons. Control subjects read the three placebo lessons.

Dependent Measure

The dependent measure was a classificatory task which required the subjects to determine which instances of an array of 38 were examples of the concept *equilateral triangle* and which were not. The majority of the instances comprising the array were taken from a probability analysis conducted earlier and represented a range of difficulty. None of the instances included in the rational sets of the various lessons were presented on the dependent measure.

The dependent measure was presented in a printed booklet similar in form to the lesson booklets. The examples and nonexamples to be identified followed a brief set of instructions. Beneath each instance the words "yes" and "no" appeared. The instructions directed subjects to circle "yes" below each example and "no" below each nonexample.

Procedure

Prior to starting the experiment the subjects were randomly assigned within stratification level to the experimental conditions. Prepackaged sets of lessons for each condition were then labeled with subjects' names to insure that each subject received the appropriate lessons.

At the start of the teaching-testing session the experimenter distributed the lessons and gave general instructions concerning the purpose of the study and the procedures to be followed. A list of the most difficult words used in the lessons was then reviewed to insure that subjects had at least some familiarity with all potentially troublesome words. The lessons themselves were not read to the subjects.

Subjects were given one minute to read each lesson page. The experimenter kept time and instructed subjects to turn to the next page after each minute had elapsed. This allowed five minutes per lesson booklet. As soon as one lesson was completed the next was begun. No subject had difficulty finishing any lesson page in the time allotted.

The experimenter collected all the lessons after they had been read and then distributed the dependent measure. The directions for the dependent measure were read aloud and subjects were then permitted to work on it for as long as they wished.

Experimental Design

Conditions in which subjects read two placebo lessons and one treatment lesson were counterbalanced so that half the subjects read the treatment lesson first and half read it third. Thus the experiment employed a 3 x 8 randomized block design with three levels of reading achievement (high, medium, and low) and eight experimental conditions.

III
Results

Because the presentation of lessons was counterbalanced in Conditions 1-3, the first phase of the analysis was designed to determine if there were significant differences within each of these three conditions due to counterbalancing. A 3 x 3 x 2 analysis of variance with three levels of stratification, three types of condition, and two orders of presentation was carried out. All effects due to order were nonsignificant ($F = 1$, $p < .46$) and the data were consequently collapsed across order of presentation for further analysis.

A 3 (stratification level) x 5 (condition) analysis of variance was used to analyze the collapsed data. Only the main effect for condition was significant ($F = 11.6$, $p < .01$). Differences in means for the stratifying variable of reading comprehension were in the expected direction, however (high [30.03] > medium [28.81] > low [28.22]). The means for each condition collapsed across both presentation order and stratification level are presented graphically in Figure 1. The ordering of the conditions means was: DRS_{1-3} (33.33) > DRS_1 (30.61) > RS_1 (29.78) > D (29.04) > control (23.43). Tukey pairwise comparisons ($\alpha = .05$) revealed that each of the four treatment groups was significantly higher than the control group and that the group receiving

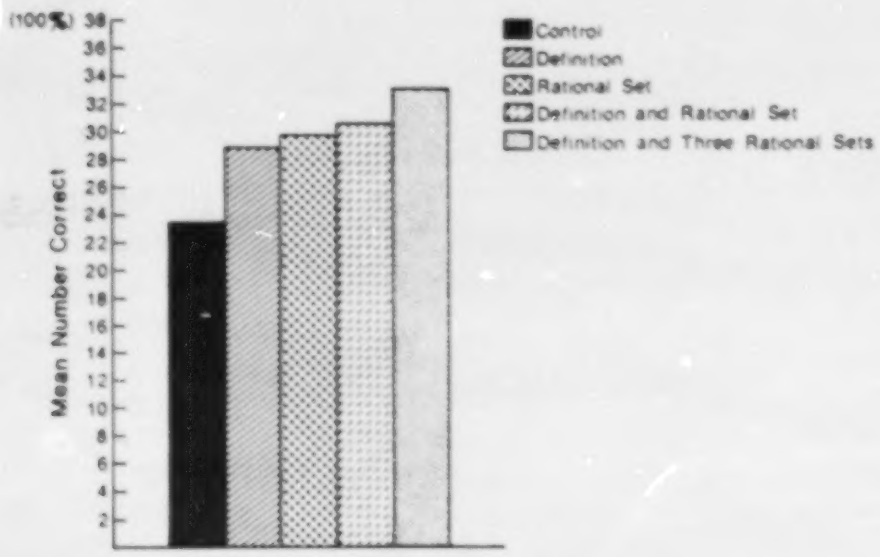

Figure 1. Mean number of correct responses on classificatory task as a function of type of information provided.

the definition and three rational sets was significantly higher than the group receiving only the definition.

The magnitude of the difference between the control group and the definition group (5.61) is assumed to be due to the facilitative effect of the definition alone. Likewise, the difference between the control group and the group receiving one rational set (6.35) represents the effect of providing a single rational set of instances. Clearly, the facilitative effects of providing a definition alone and a rational set alone were almost equal. The subjects gained additional information, however, when one rational set was presented with the definition, inasmuch as the magnitude of the difference (7.18) between this condition (DRS_1) and the control was greater than that between the control and either D or RS_1. Moreover, subjects continued to gain information from the two additional rational sets which were presented (DRS_{1-3} - control = 9.90).

IV
Discussion

The purpose of this study was to determine the precise effects on concept attainment at the classificatory level of providing a concept definition, a rational set of examples and nonexamples, a definition and a rational set, and a definition with three rational sets. It was found that subjects learned a significant amount from each of these instructional conditions. Specifically, subjects were found to learn an equal amount from either a definition or a rational set, slightly more (although not significantly so) from a combination of the two, and significantly more from a definition and three rational sets. The difference in performance between subjects presented with a definition and subjects presented with a definition and three rational sets was an increase on the dependent measure from 76% correct to 88% correct ($p < .05$). These findings are consistent with those of Feldman (1972) and Merrill and Tennyson (1971).

The importance of the present findings for educators appears to be far-reaching. Instructional materials to teach concepts can be prepared according to increasingly definitive guidelines which have been empirically demonstrated to facilitate learning. In particular, presenting materials that contain a definition of the concept and different rational sets of examples and nonexamples appears to result in substantial learning in relation to the small amount of time spent by the students.

The findings also may interest theorists in the field of conceptual learning. Earlier, we stated that CA = f(EX + EM + D + O) x IC. Let us assume that the internal conditions (IC) can be represented by the control subjects' mean score. That is, this test score represents attentiveness, knowledge, and the mental operations of individuals as related to the particular concept or set of concepts to be attained. Let us assume further that the scores on the attainment tests reflect reliably how much was learned and that what was learned was an effect of the treatments as described. Using the control subjects' mean score of 23.43, DRS_1 mean score of 30.61, RS_1 mean score of 29.78, and D mean score of 29.04, we can enter the values for Condition DRS_1 into the equation thus:

(a) CA (30.61) = RS_1 (6.35, or 29.78 - 23.43) + D (0.83, or 30.61 - 29.78) x IC (23.43 score of the control group); or

(b) CA (30.61) = D (5.61, or 29.04 - 23.43) + RS_1 (1.57, or 30.61 - 29.04) x IC (23.43 score of control group).

From (a) we may infer the effects of a single rational set (RS_1) and of a definition (D) when a definition is added to make DRS_1; and from (b) we may infer the effects of a definition (D) and a single rational set RS_1 when a rational set is added to make DRS_1. Further research is needed to specify more clearly the effects of adding rational sets, with and without presenting a definition. Also, the effects of emphasis and other variables in relation to the present variables must be established. It appears that these effects may be identified and related to the present ones and that the equation may then be developed more precisely in terms of the interacting contributions of each variable.

Finally, it is important to point out that although the concepts used in the studies of Feldman (symmetry), Merrill and Tennyson (poetry), and in the present research (equilateral triangle) were all quite different, the findings are the same regarding the effects of rational sets of examples and nonexamples and concept definitions. Therefore, it is reasonable to assume that the results of these studies would generalize to other concepts which can be defined in terms of attributes.

Moreover, since Feldman worked with sixth-graders, Merrill and Tennyson with college students, and the present research used fourth-graders, it is probable that the results would generalize across grade levels as well, with the possible exception of those at which children cannot yet read well with independence.

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